

UNCLASSIFIED

AD 270 880

*Reproduced
by the*

ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

WADC TECHNICAL REPORT 57-477 (II)

270 880

HIGH ALTITUDE BALLOON DUMMY DROPS

II: THE STABILIZED DUMMY DROPS

RAYMOND A. MADSON, 1ST/LT, USAF

LIFE SUPPORT SYSTEMS LABORATORY
AEROSPACE MEDICAL LABORATORY

AUGUST 1961

NO. 075

AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>(over)</p> <p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>

<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p> <p>(over)</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>

HIGH ALTITUDE BALLOON DUMMY DROPS

II: THE STABILIZED DUMMY DROPS

RAYMOND A. MADSON, 1ST/LT, USAF

*LIFE SUPPORT SYSTEMS LABORATORY
AEROSPACE MEDICAL LABORATORY*

AUGUST 1961

PROJECT No. 7222
TASK No. 71748

AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

FOREWORD

This study was made by the Escape Section of the Biophysics Branch, Aerospace Medical Laboratory, under Project 7222, "Biophysics of Flight," Task 71748, "Escape." 1/Lt Raymond A. Madson was project monitor.

Support was given by numerous individuals and organizations at this Division and Holloman Air Force Base, New Mexico. Major support was given by Mr. Francis J. Beaupre, Mr. Kenneth D. Arnold, Capt. Henry P. Nielsen, Capt. Noel P. Thompson, Lt John F. Rayfield, and Capt. J.W. Kittinger, Jr., of the Aeronautical Systems Division; and the Balloon Branch, Air Force Missile Development Center, Holloman AFB, New Mexico.

WADC Technical Report 57-477 (I), High Altitude Balloon Dummy Drops, Part I, The Unstabilized Dummy Drops, reported the preliminary phase of this study and the results justified continuation of the phase reported herein.

ABSTRACT

This study was a part of a program to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.

PUBLICATION REVIEW

Wayne H. McCandless
WAYNE H. McCANDLESS
Chief, Life Support Systems Laboratory
Aerospace Medical Laboratory

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SERIES I	1
Instrumentation	1
Photographic Coverage.	2
Instrument Kit Attachment	3
Equipment Recovery Attachment	3
Parachute Development	3
Dummy-Balloon Attachment	4
Test Preparation	4
Test Program	5
Test Results	6
SERIES II	7
Instrumentation	7
Photographic Coverage.	8
Parachute Development	8
Dummy-Balloon Attachment	9
Test Schedule	10
Test Results	10
INTERIM SERIES OF DROPS.	11
Test Results	11
SERIES III	12
Instrumentation	13
Photographic Coverage.	13
Instrument Kit Attachment	15
Parachute (Development).	15
Dummy-Balloon Attachment	15
Data Collection	16
Test Results	16
CONCLUSIONS	18
APPENDIX I	19

HIGH ALTITUDE BALLOON DUMMY DROPS

II. The Stabilized Dummy Drops

INTRODUCTION

In October 1952, WADC Technical Report 57-477, "High Altitude Balloon Dummy Drops, Part I, The Unstabilized Dummy Drops," concluded that continued research was necessary to develop a means of stabilizing a man falling from altitudes above 20,000 feet. In 1958, Mr. Otto Walchner (ref. 1) completed a study proving that it was theoretically possible for a man free-falling from 83,000 feet to develop a spin rate of 465 rpm through the vertical axis while the body is prone. Walchner's study added technical knowledge and incentive to investigate and develop stabilization methods that would permit a man to bail out of a vehicle at high altitude and descend without tumbling, spinning, or rotating.

The second phase of the research effort was divided into Series I, Series II, and Series III. Some of the equipment used in this second phase was unchanged from that used in the first phase reported in Part I. Holloman Air Force Base remained the test site, the dummies were the same type previously used, and the same mobile launch technique was used. Major changes were made in instrumentation, parachute configuration, data collection, and other related areas. Each series incorporated changes in instrumentation and parachute configuration.

SERIES I

The Series I tests began in the latter part of 1955 and were completed in May 1956. These tests ran concurrently with the last of the unstabilized dummy drops.

Instrumentation

Instrumentation for Series I drops was the same as that used during the unstabilized drops. It included the same 11 accelerometers ranging from 6 to 10 g (figure 1), which fed data into a recording oscillograph, and a modified N-6 GSAP 16 mm camera with a wide-angle lens. In addition to that used in the unstabilized drops, there were two pressure transducers mounted within the kit, and a camera mounted on the dummy's shoulder. Pressure data were collected by mounting a pitot tube on the dummy's foot and running two hoses from the tube to external kit connections of the transducers. One

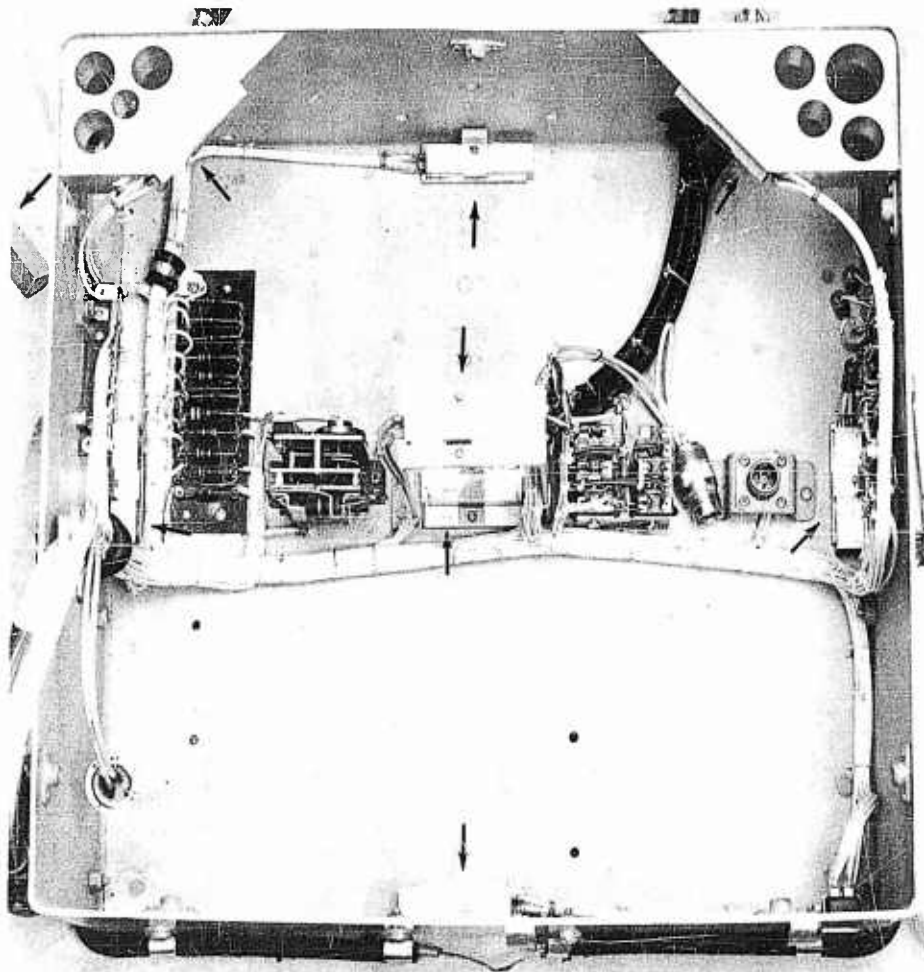


Figure 1. Accelerometers in Series I Instrumentation

transducer recorded ambient pressure, while the other recorded differential pressure on the falling dummy. The shoulder-mounted camera was aimed upward, relative to the dummy in a standing position, to record functional characteristics of the stabilizing parachute. The entire instrument system, powered by a battery pack in the kit, was activated by the radio command that initiated dummy release.

Considerable difficulty was encountered in obtaining valid data from the instrumentation mentioned above. The instruments and electronic components had been used on the unstabilized drops and became increasingly unreliable due to the rough treatment from the tests. The oscillographs and accelerometers, once accurate and productive, began giving false readings during the tests, and on occasion, failed completely. The transducers gave no data and the cameras provided a minimum of information.

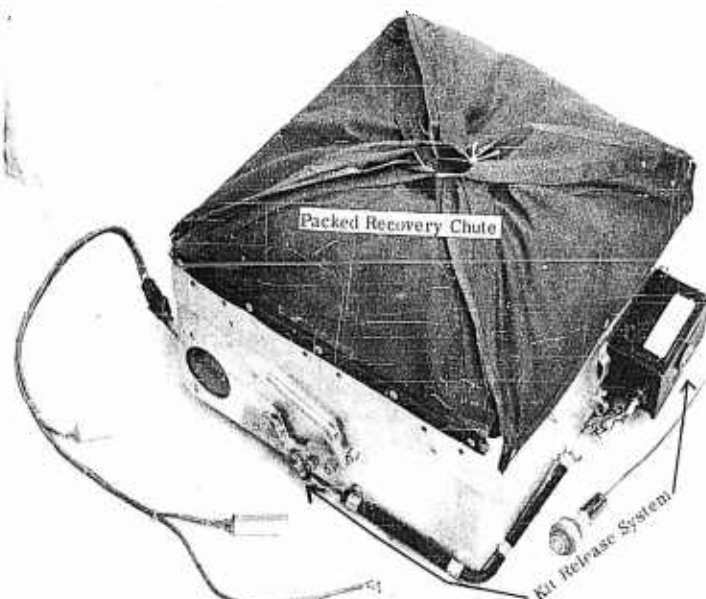
Photographic Coverage

The design of the test package limited photographic coverage to two cameras—one in the instrument kit and the other mounted on the dummy's shoulder. The kit camera was mounted on the inside of the kit shell and aimed out through a plastic window to record the dummy's position and motion relative to the earth's surface. The shoulder camera recorded deployment and action of the drogue chute.

Instrument Kit Attachment

During the first stages of the unstabilized dummy drops, attempts were made to recover the instrument kits attached to the dummies. However, the dummies landed on the kits, crushing, or damaging the instruments. Therefore, a new system incorporating an automatic parachute release armed by a static line was developed to separate the kit from the dummy after the dummy's main parachute had opened. As the kit dropped away, the static line on the kit deployed the kit-recovery parachute (figure 2).

Figure 2. Kit Recovery System

Equipment Recovery Attachment

The above method of kit attachment was used in both Series I and II. It proved satisfactory in most instances, but created problems for recovery crews, because they had to recover five items: two dummies, two kits, and one balloon. The shortage of recovery support vehicles and the uncertainty of impact points made recovery of the test equipment difficult. Most of the equipment was found eventually; however, there were occasions when the delay resulted in loss of data, because the tests items had been exposed to severe weather conditions.

Parachute Development

Since Series I and the unstabilized drop tests were conducted at the same time, some multistage parachutes were "hitch-hiked" on unstabilized dummy drop flights. The first multistage configuration tested in Series I (stabilized drops) was a B-4 pack incorporating a 5-foot drogue chute, which was deployed by a static line when released from the balloon. The dummy, with the drogue chute deployed, was programmed to fall to 15,000 feet where the main canopy was set to deploy automatically. As soon as the main canopy deployed, the test duplicated a routine parachute jump. Two dummies were launched with this configuration and both parachutes failed.

The second configuration tested in this series was an automatically deployed 5-foot stabilization chute combined with a standard B-5 pack (figure 3). The chute was deployed by an automatic parachute release timer with the aneroid timer removed. This timer was activated by a static line as the dummy was released. Following a preset period of free-fall, the timer "fired" and deployed the first-stage parachute. Two drops were made with this configuration, and again both assemblies failed. The malfunctions were traced to snagged risers which prevented the parachute system from operating.

Dummy-Balloon Attachment

Figure 3. Five Float Drogue Chute Combined with B-5 Pack

Test Preparation

Test preparation for Series I drops paralleled that outlined in WADC TR 57-477, Part I. The initial preparation of the test equipment for all three series is discussed here.

Initial preparation for a test began with the instrumentation check. Each kit was checked for faulty electronic components, and the instruments were adjusted as necessary. After the kits were inspected, each dummy's instrumentation package was assembled for a systems-check. When the separate dummy systems proved operable, the entire instrumentation package was integrated for a systems-continuity check and pretest schedule run.

Concurrent with the instrumentation preparation, the dummies were being dressed and mounted on the launch rack. The experimental parachutes were fitted to the dummies and a chest reserve parachute added to one of the dummies. (This practice was established to determine if there was any appreciable difference in

Since Series I drops were integrated with the unstabilized drops, the method of attaching dummies to the balloon remained the same. The dummies were attached below the balloon instrument package with the suspension lines threaded through squib-fired cutters (figure 4). The dummies were released from the balloon via ground radio command through the balloon instrument kit; Dummy No. 1 preceded Dummy No. 2 by 5-10 seconds. Dummy No. 2 was delayed to prevent any possibility of one dummy fouling the other's equipment during descent. As Dummy No. 1 was released, it would drag and scrape down the torso of Dummy No. 2 until it was free of the balloon-borne package. The close contact at cut-down endangered the equipment worn by either or both dummies, and thereby the test results.

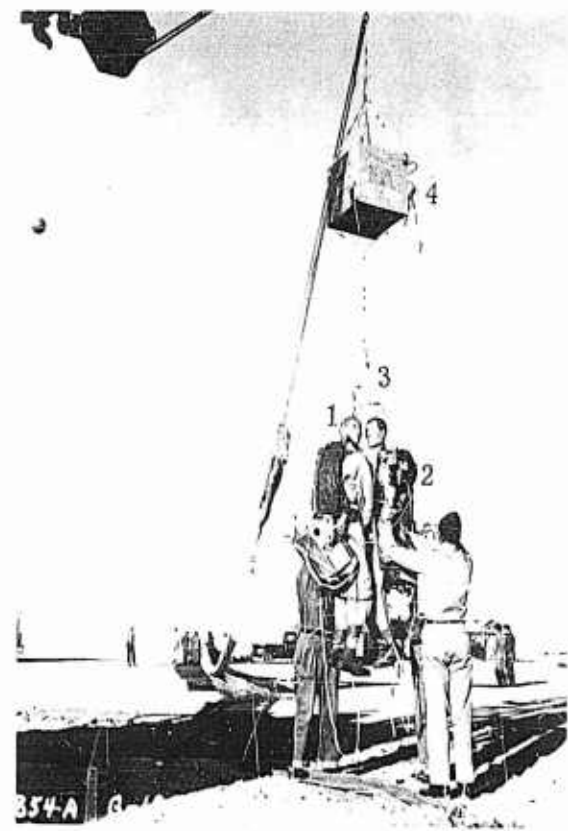


Figure 4. Series I Dummy-Balloon Attachment
 1. Unstabilized Dummy
 2. Stabilized Dummy
 3. Cutters
 4. Cut-Down Command Box

the aerodynamic characteristics of bodies falling with or without a chest reserve parachute.) The "rigged" dummies were hoisted above the launch rack and dropped into position where they were tied with temporary suspension lines. After the dummies were suspended correctly, permanent suspension lines were threaded between each dummy's back and parachute, under the arms, through squib-fired cutters, and then tied to the suspension bar in the rack top. Once the dummies were permanently suspended, the instrument kits and shoulder cameras were installed, and the shoulder camera was aimed toward the predicted open drogue-chute position. The completed test package, minus the rack camera boxes and balloon instrument, was then loaded onto a truck for transportation to the launch site. The remaining camera and instrument kits were carried to the launch site in "easy-riding" vehicles to avoid unnecessary bumping and jostling that might result in instrument malfunction.

Test Program

The majority of stabilized dummy drops were launched from remote sites so the dummy could be released over the well-instrumented missile test range impact areas. This practice afforded camera and radar tracking of the dummy's flight and descent, facilitated recovery, and provided additional test data. Support vehicles were loaded with the test equipment and dispatched to a predicted general launch area on the day preceding the launch. At midnight the launch-crew chief contacted Balloon Operations at Holloman AFB to obtain information on, and location of, the exact launch site. The launch team then departed for the selected site. This procedure was followed to minimize travel time required to reach a given site, and thereby provided ample time for assembling and preparing the entire test package on location.

Preparation for launch was conducted in accordance with a detailed "Procedure and Check list" (appendix I). The first task was to inspect the dummies and instrumentation to insure that no damage or disconnects occurred enroute to the site. Following the inspection the camera kits and balloon instrumentation were mounted on the rack. After all electrical leads were connected, the camera lenses were wiped clean and adjusted, and the rack was lifted so the truck could be moved. The rack brace was then removed, and the telemetry antenna installed on Dummy No. 1. The last step before launch was to arm the kits by depressing external switches mounted on them.

While the test package was being prepared, the balloon was being readied for the flight (figure 5). Thereafter, the balloon was launched (figure 6).

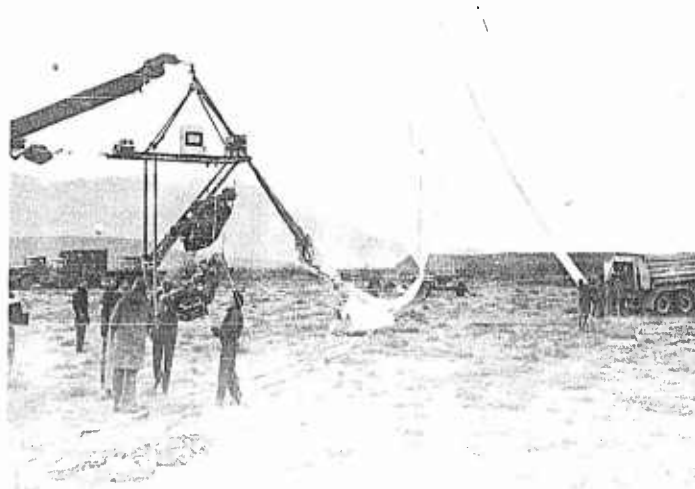


Figure 5. Launch Preparation



Figure 6. Balloon Launch

As the balloon's trajectory carried it over the instrumented impact area, cut-down was initiated by a radio command from the ground. The command signal activated test-package instrumentation which started the recording instruments and sequenced release of Dummy No. 1 and, after a short delay, Dummy No. 2.

Following dummy release, the launch rack was cut from the balloon and descended on its 64-foot cargo recovery parachute. The drop was considered complete when all portions of the test package were recovered and delivered to the Balloon Branch at Holloman AFB.

Test Results

The drop numbers of the runs do not follow each other consecutively, since drops in Series I were conducted in conjunction with the unstabilized dummy drops. Instead, they reflected the transition from unstabilized to stabilized tests as the state-of-the-art progressed.

- Drop 051: 26 November 1955, 128-foot balloon with two dummies ascended to 88,000 feet. Following launch, inclement weather set in and prevented tracking and immediate recovery. Dummy No. 1 was recovered first and was found to be damaged. Data indicated that a spin of at least 81 rpm was experienced. It was definitely established that the parachute had malfunctioned. Dummy No. 2 was recovered in 1958 in a severely weather-beaten and damaged condition. The instrument kit was never found, but it is known that the parachute had malfunctioned.
- Drop 056: 18 May 1956, 128-foot balloon with two dummies (one unstabilized and one stabilized) ascended to 89,000 feet. Dummy No. 2 (stabilized) became tangled in the risers during first stage deployment and free-fell to the ground. All instrumentation was demolished and no data was recovered.
- Drop 057: 22 May 1956, 128-foot balloon with two dummies (one unstabilized and one stabilized) ascended to 90,300 feet. Dummy No. 2 (stabilized) became tangled in the risers and free-fell to the earth. The instrumentation was demolished and no data was recovered.

Little usable data was collected in Series I. Since most of the equipment was damaged and the tests gave no indication of successful parachute performance, series I was concluded at this point and the project personnel began development of new systems and equipment.

SERIES II

Series II began in May 1957 and was completed in June 1957.

Instrumentation

The instrumentation kit for Series II was redesigned. It incorporated two 10-g accelerometers to measure transverse and lateral forces, two pressure transducers to measure ambient and differential pressures, two modified N-6 GSAP cameras (one inside the kit and one shoulder mounted) and all additional necessary electronic equipment (figure 7). This kit eliminated nine accelerometers, incorporated different transducers, and made other changes in kit calibration, activation, and operation. These changes in kit design resulted in various problems of integration with personal equipment, checkout, and maintenance not previously encountered. As the second series of drops progressed, it became increasingly evident that data collection with this instrumentation was also unsatisfactory because of extreme environmental conditions.

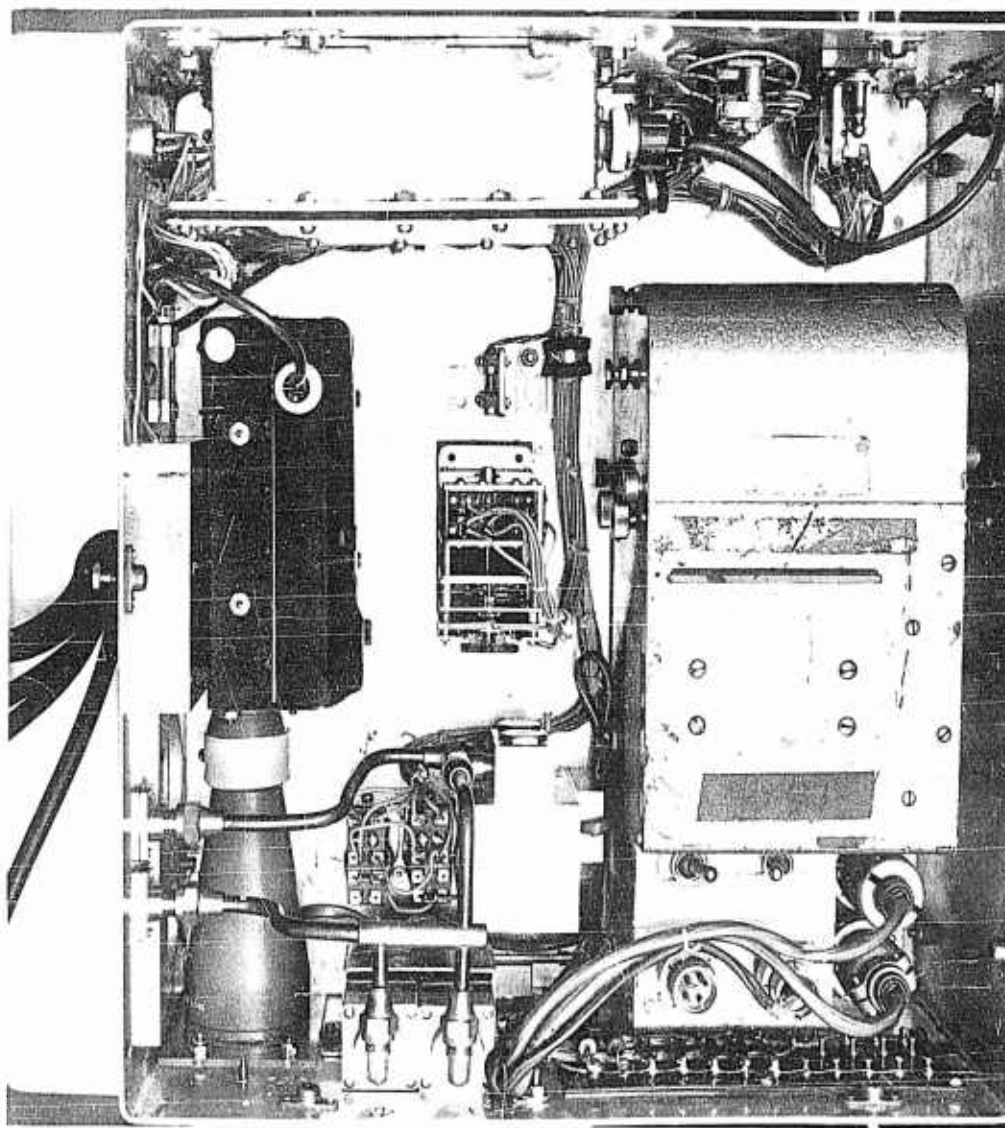


Figure 7. Series II Instrument Kit

Photographic Coverage

During this Series, a new dummy-launch rack incorporating a camera box and a cut-down command box was used. The camera box contained three N-6 GSAP cameras, each equipped with a different focal length lens ranging from an 84 degree wide angle lens to a 4-inch telephoto lens (figure 8). Later modifications in this Series incorporated two additional rack-mounted cameras, and the previous camera box and the command cut-down box were relocated. The rack-mounted cameras collected sufficient data from which we determined the parachute required further development. During Series II, these cameras became the primary instruments for collecting data. Dummy-borne cameras remained mounted on the dummy's shoulder as in Series I tests. Due to the problems of static-line deployment, motion picture coverage of dummy release and first-stage deployment were mandatory.

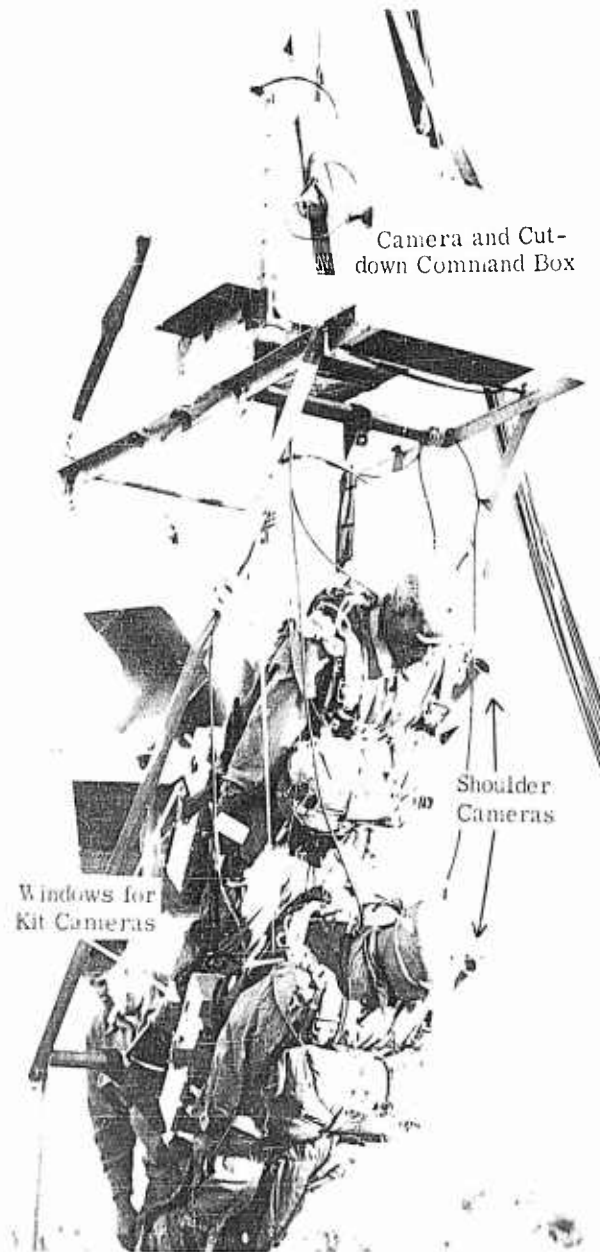


Figure 8. Series II Camera System
 1. Camera and Cut-Down Command Box
 2. Shoulder Cameras
 3. Windows for Kit Cameras

Parachute Development

A static-line-deployed 6-foot stabilization parachute integrated with a standard B-5 pack (figure 9) was used during this Series. The assembly was tested by numerous aircraft drops before it was proved for use in the balloon project. As these tests began concurrent dummy and live jump tests were conducted

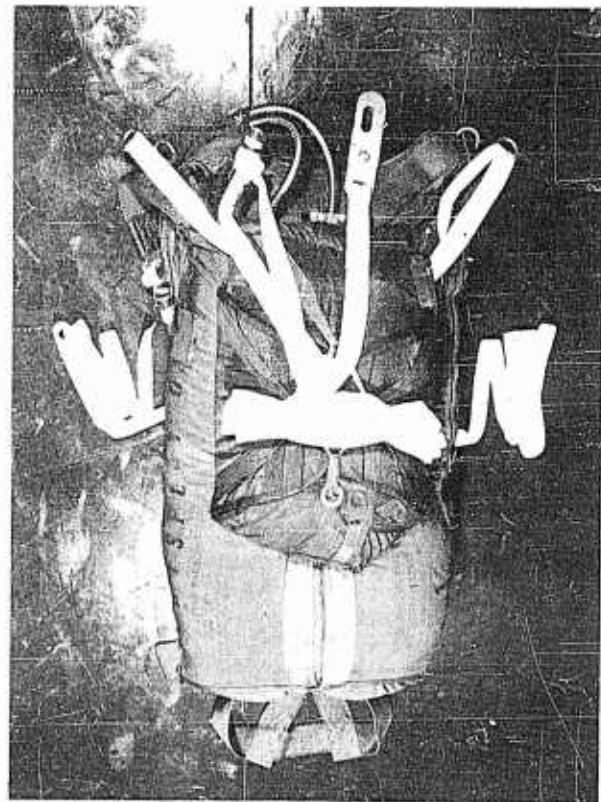


Figure 9. Static Line Deployed Six Foot Drogue on B-5 Pack

from aircraft at El Centro, California. Although the aircraft tests were successful, data from the balloon drops indicated that stabilization chute reliability at high altitudes was unsatisfactory due to the low velocity at time of deployment. However, the information gained was encouraging when compared with Series I. Of the 10 dummy drops from altitudes up to 88,000 feet, 7 dummies were recovered and 3 free-fell to earth due to malfunctions. The main difficulty encountered was the tendency of the dummies to snag or tangle in the stabilization chute risers before the first stage could fully inflate. The rack-camera film showed that two of the successfully recovered dummies had fouled in their drogue chutes during deployment, but had apparently untangled prior to, or upon reaching, main canopy deployment altitude.

Dummy-Balloon Attachment

A rigid dummy-launch rack was designed and fabricated. It accommodated two diagonally suspended dummies, radar reflectors, a camera box, and a cut-down command box (figure 10). The rack was suspended by a harness which supported the balloon instrument kit and attached to the test package recovery parachute. This parachute linked the balloon to the test package (figure 11). Dummies launched from this diagonal position were immediately thrown into a tumble, thereby inducing the worst possible condition for first-stage deployment. After several drops in this configuration, it was decided to test first-stage deployment under optimum conditions. The rack was modified to permit vertical suspension of the dummies and the camera box and the cut-down command box were relocated to provide complete coverage throughout the dummy-release profile (figure 12). This configuration was employed on the last two Series II drops.

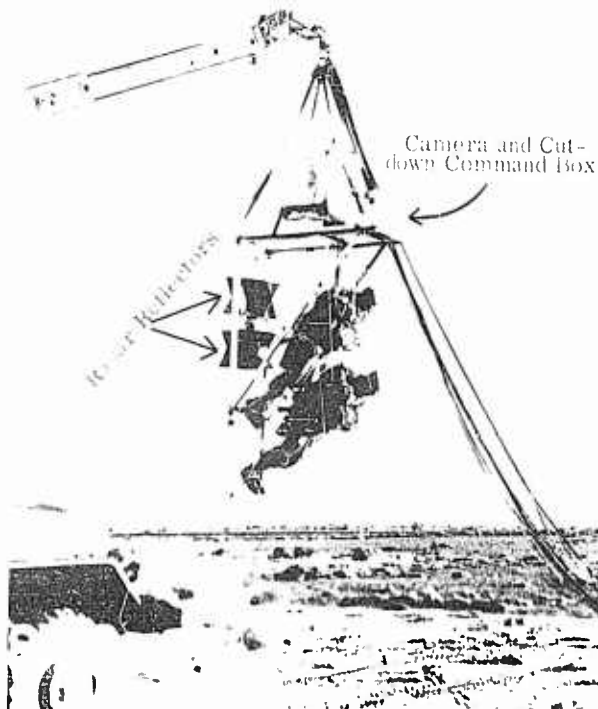


Figure 10. Series II Dummy Launch Rack
 1. Radar Reflectors
 2. Camera and Cut-Down Command Box

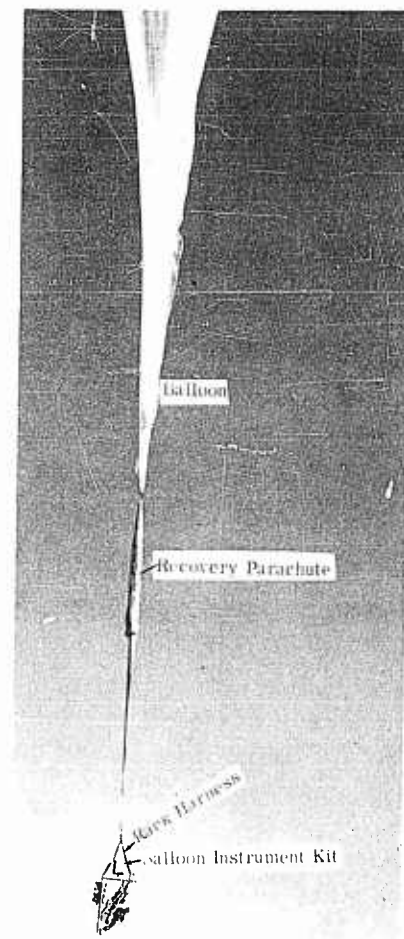


Figure 11. Launch Rack-Balloon Attachment

Test Schedule

Radar, optical cameras, and theodolite tracking collected data on descent time and velocities of the dummies in Series II and III drops.

Test Results

Drop 058: 29 May 1957, 128-foot balloon ascended to 84,000 feet. The parachute on Dummy No. 1 functioned as desired, but stabilization chute deployment was sloppy. Dummy No. 2 tumbled into the risers during first-stage deployment and failed the parachute system. The dummy free-fell to the ground, but the instrument kit separated as planned; the data from this drop was not readable.

Drop 059: 4 June 1957, 128-foot balloon ascended to 84,000 feet. Cut-down was attempted, but without results, and the dummies rode the rack to the ground. The rack-camera film showed that an electrical line on Dummy No. 1 had disconnected during or following launch and prevented the dummy from releasing. Long after the rack cameras had been activated, Dummy No. 2 was seen falling on Dummy No. 1, confirming the electrical disconnect malfunction. This launch was considered as "No Test."

Drop 060: 6 June 1957, 128-foot balloon ascended to 86,000 feet. The stabilization chute of Dummy No. 1 fouled under the chest reserve parachute and the dummy free-fell to the earth. The kit was recovered satisfactorily, but the data was incomprehensible. The parachute on Dummy No. 2 functioned properly after a very poor first-stage deployment. Opening shock of the instrument kit recovery parachute snapped one of the kit-parachute attachments, which resulted in the kit streaming to the ground, damaging all data.

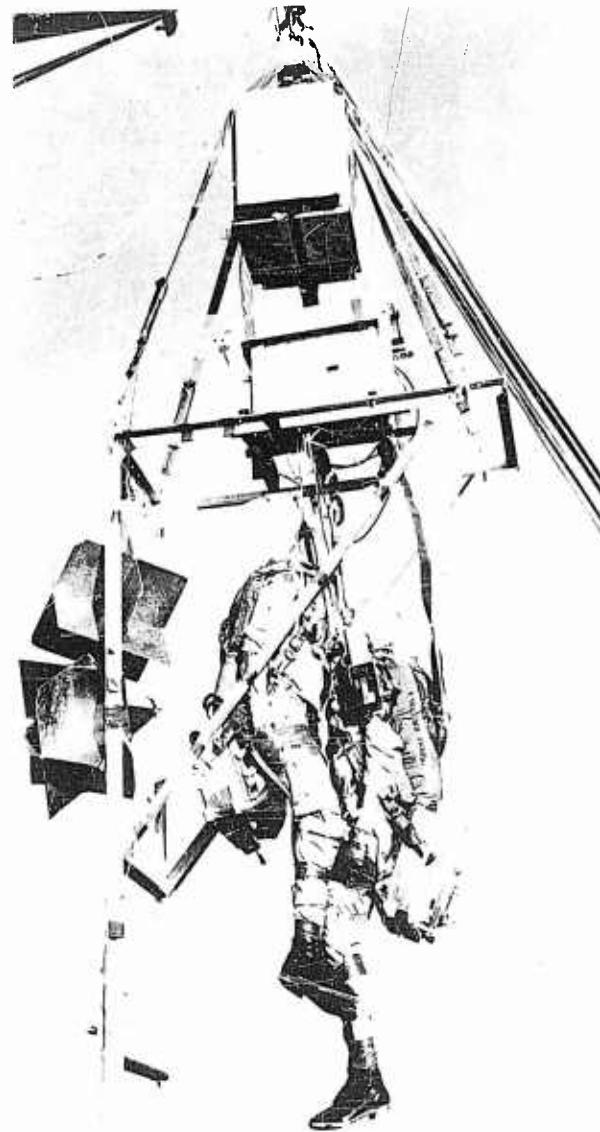


Figure 12. Modification for Vertical Dummy Suspension

Following Drop 061, the dummy-launch rack was modified to test deployment of the stabilization chute under the most favorable conditions. This was done by providing a suspension bar from which the dummies could be suspended in a vertical position. The camera box and the cut-down box were also moved to allow motion picture coverage of the dummies from the time they were released until they vanished far below the rack.

Drop 062: 11 June 1957, 128-foot balloon ascended to 81,000 feet. The parachute system on Dummy No. 1 functioned correctly after a rather poor first-stage deployment. The instrument kit, recovered as planned, gave only incomprehensive data. The parachute system on Dummy No. 2 functioned satisfactorily and a stabilized fall with 26 rpm rotation rate ensued.

Drop 063: 13 June 1957, 128-foot balloon ascended to 83,000 feet. Again, both dummies were satisfactorily recovered, but the instrument kits collected no comprehensive data.

Drop 063 completed the scheduled launches in Series II. The rack-mounted cameras provided invaluable information by recording the sloppy characteristics inherent in using a static-line deployed stabilization chute. The malfunctioning kit cameras prevented collection of data necessary to evaluate the Series II multistage parachute accurately. It was believed that the optimum dummy release conditions employed in the last two drops accounted for the successful test results. Although the parachute could be made to function correctly, it was still considered inferior for live jump tests from a balloon-borne vehicle. To be completely reliable, a parachute had to operate equally well under adverse and optimum deployment conditions. Since every malfunction of this system involved tangling of the dummy in the risers during first-stage deployment, two new concepts were advanced for development and investigation in an attempt to eliminate this problem. The first of these was tested on the interim series of drops from balloon-borne gondolas.

INTERIM SERIES OF DROPS

After the Series II tests were completed and before the Series III tests, a series of drops from balloon-borne gondolas was made in September and October 1957. During this period, an attempt was made to correct the fouling problem by substituting a single elongated riser system (figure 13) for the two riser configuration. This assembly was used in conjunction with two gondola test flights with one dummy "hitch-hiking" on each gondola. Both stabilization chutes deployed properly, but due to faulty release systems, the dummies, with their main canopies unopened, rode the stabilization chutes to the ground. Although the interim fix was apparently satisfactory, static-line deployment of the first stage was still not considered satisfactory, so new designs were investigated. An interim parachute system was tested in conjunction with test flights of two gondolas programmed for use in a live jump-test phase of the project. One dummy was mounted on each of the gondolas (figure 14). As the gondolas reached float altitude, the dummies were released by radio-command-fired cutters and the drop profiles resembled those in the first tests of Series II.

Test Results

Drop 064: 27 September 1957, 177-foot balloon ascended to 96,000 feet with one dummy mounted on the gondola. Following dummy release, the first-stage chute deployed satisfactorily and functioned

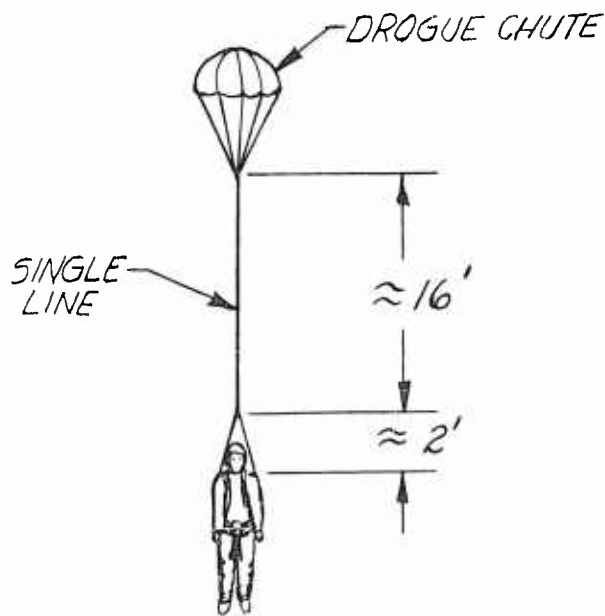


Figure 13. Single Elongated Riser System

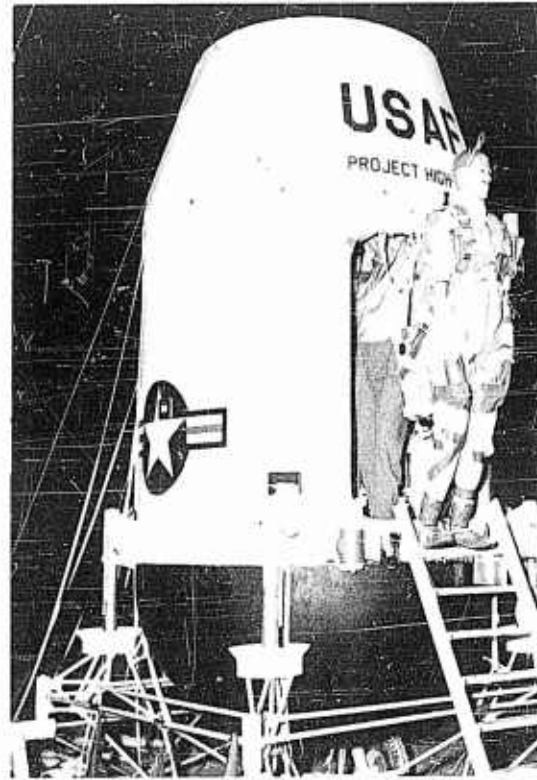


Figure 14. Dummy Mounted on Gondola

throughout the descent. A release mechanism, used for first-stage separation and main canopy deployment, failed to operate, and the dummy rode the stabilization chute to the ground. The instrument kit also failed to separate and all of the data was lost as the kit was smashed on impact.

Drop 065: 8 October 1957, 116-foot balloon ascended to 57,000 feet with one dummy mounted on the gondola. Following dummy release, the results duplicated those of the previous drop (Drop 064). All instrumentation was demolished and the data lost.

SERIES III

Considerable time elapsed between Series II and III, and in this period many changes occurred in the project. A new parachute assembly was developed, new instrumentation fabricated, closer coordination with Holloman AFB was established, and the entire project took on a new look. Previously, the tests had been conducted with a minimum of Wright Air Development Command support personnel accompanying the project to Holloman. Series III tests were begun in January 1959 and were completed in February 1959. A qualified technician advisor was present for every integral system. Each individual documented work done in his area of responsibility and the results and/or operation of this equipment. The data collection efforts of the team were further supplemented by programming for use of the Air Force Missile Development Center - White Sands Proving Ground "Integrated Range" tracking instrumentation. Due to this increased concentration on data collection, complete information was gathered on Series III drops.

Instrumentation

While preparing for Series III, an effort was made to insure complete photographic coverage by the test package cameras. The external kit surfaces were painted black to absorb heat and the kit cameras were insulated with plastic bottles containing water at ground-level temperature (figure 15).

A second problem was recording opening-shock and load-time characteristics of the first-stage parachute. New means of gathering this information were investigated, since the recording oscillographs had failed rather consistently. We decided to try telemetry in the third series of drops. To measure the first-stage forces, a variable resistance load ring was installed between the risers of the drogue chute and the apex of the main canopy. As the drogue chute deployed, changes in the load ring resistance were fed into a transmitter in the kit, and then to a telemetry antenna mounted between the dummy's feet. Due to the test range frequency limitations, only one dummy per flight could be instrumented with telemetry, and the antenna location required that this be Dummy No. 1. Dummy No. 2 was instrumented with a kit containing only one camera and electronic components to accommodate the kit camera and the shoulder camera.

With this instrumentation system, it was possible to obtain data required to evaluate the functional characteristics of the parachute being tested in Series III.

Photographic Coverage

The dummy-borne cameras in Series III again duplicated those used in Series I and II, but the rack-camera concept changed considerably. Traid 100 movie cameras replaced the N-6 GSAP's, and a P-2 70 mm sequence still camera was added to the system. The P-2 camera, mounted on an extension at the rear of the rack, contained its own power supply, and was used to capture the motions of the dummies upon release from the rack. This final configuration provided adequate data to determine the functional characteristics of the Series III parachute. Figures 16 and 17 are examples of photographic coverage by the P-2 camera showing the dummies after release from the rack.

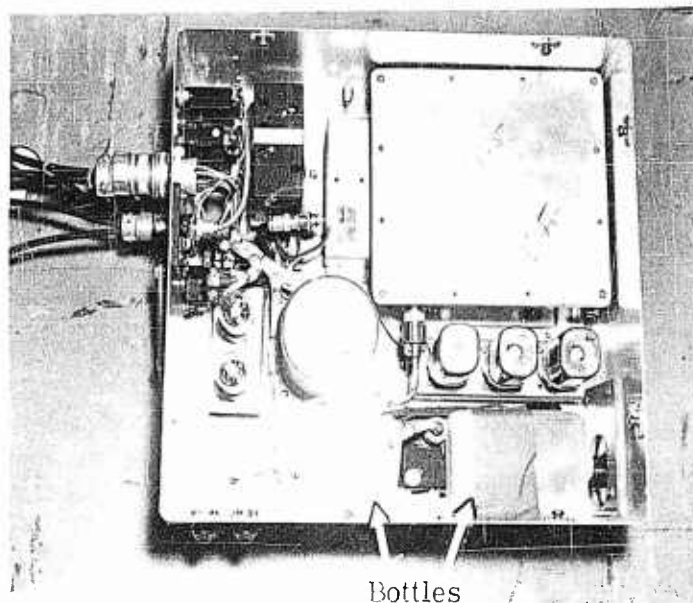


Figure 15. Insulation Bottles Around Kit Camera



Figure 16. Dummy No. 1

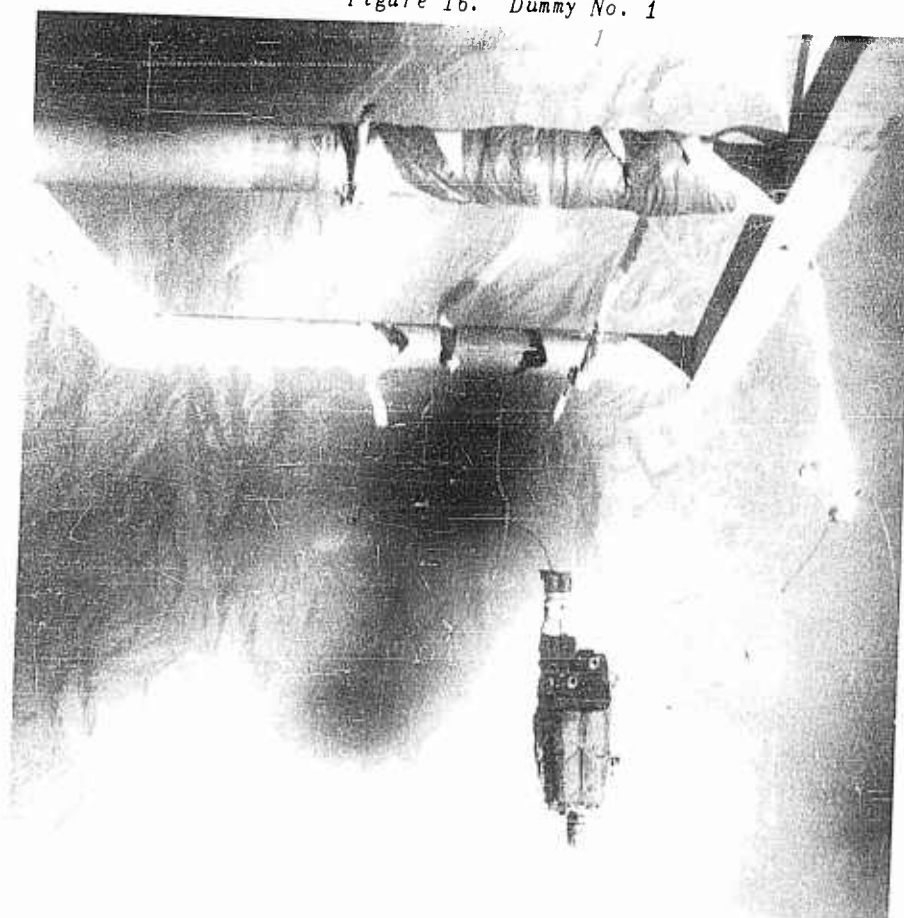


Figure 17. Dummy No. 2

Instrument Kit Attachment

For this series of drops we planned to recover the kit on the dummy again. Due to the kit design, however, one side of the kit had to be released to allow a spring-loaded switch to close. This switch, held open by the closed kit release clamp, turned the kit electronic system off after the dummy's main chute deployed. The kit shell was built stronger and styrofoam padding was placed on the top and bottom to withstand forces resulting from dummy impact. A nylon safety line connected the release side of the kit to the parachute harness, thereby preventing the kit from dangling too loosely. This minimized the kit's free-travel distance from the dummy and at the same time eliminated damage at impact that might have resulted from an excessively rigid kit-dummy attachment. It was later inadvertently demonstrated, through a first-stage release malfunction, that the kit construction, aided by styrofoam padding and the loose attachment, could withstand impact forces resulting from near-terminal velocity and suffer very little damage. This method of recovery was used throughout Series III.

Parachute (Development)

Series III incorporated a major change in the stabilization concept. In contrast to all previous "piggy-back" stabilization-chute configurations, the final multistage parachute had the appearance of a B-5 pack (figure 18). It employed two automatic parachute release timers that were activated by static line as the dummy left the balloon. The first release, with the aneroid assembly removed, deployed the stabilization chute and three quarters of the main canopy. The main canopy functioned as suspension lines for the drogue chute until the dummy descended to 17,000 feet, where the second parachute release fully deployed the main canopy.

Several drogue-main canopy combinations were tested (i.e., 5-foot drogue; 24-foot main; 5-foot drogue; 28-foot main; and 6-foot drogue; 28-foot main), and every configuration gave satisfactory deployment and stabilization results. The assembly providing the most favorable results was the 6-foot drogue, 28-foot main canopy combination.

Although deployment and stabilization proved satisfactory, the first-stage disconnect system failed twice in 18 tests.

Dummy-Balloon Attachment

The rack was similar to that used in Series II; however, certain modifications were necessary due to changes in the parachute configuration and drop profile. These included: an easily disconnected rack brace to permit the rack to stand unsupported while launch preparations were made (ballast allows greater balloon flight control) and an

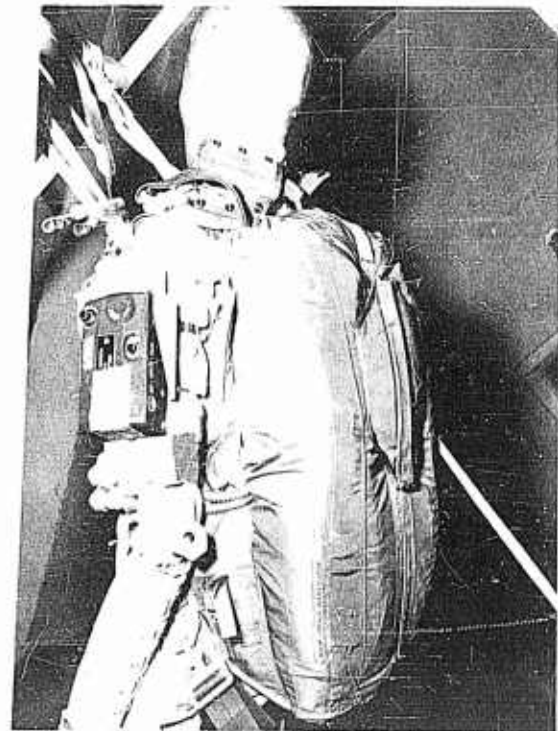


Figure 18. Series III Parachute (Resembles Standard B-5)

extension of the rack top was made to accommodate a complete and independent camera system. The dummies were suspended from the rack in a back-down position to insure that the automatic parachute release lanyards were activated cleanly. Due to the location of the arming lanyard knobs, any other method of suspension might have resulted in the lanyards breaking rather than arming the release. This rack configuration was used throughout Series III.

Data Collection

Radar, optical cameras and theodolite tracking were used to collect data on descent time and velocities of the dummies in these drops also. Data was collected by viewing the kit-camera film on a stop-frame projector with a hand crank and frame counter. Since the cameras were modified to run eight frames per second, it was only necessary to record the number of frames required for the dummy to make one revolution and divide by eight. Multiplying the results by 60 gave the rpm at any given point. Each individual revolution was recorded on a graph and the end result was a chart showing the complete rpm history on the drop (see appendix II).

Additional data, collected and reduced by Land-Air Incorporated consisted of an accurate time-altitude-velocity account of each dummy from 20 seconds preceding release to dummy impact. This information was furnished to the project officer following each balloon flight.

Test Results

Certain characteristics appeared on every test in this series. Therefore, they will be presented as general information before discussing the individual tests:

1. The stabilization chute deployed cleanly and effectively on every test. This demonstration of reliability eliminated the greatest problem area encountered up to Series III first-stage deployment at altitude.
2. Opening shock of the first-stage parachute did not exceed 3 g, proving that this did not constitute a problem area.
3. The maximum rotation rate recorded was 30 rpm through the vertical axis of the body in a standing position. Since figure skaters on ice routinely experience similar rotations, but in excess of 120 rpm, the forces encountered in these tests were well within human tolerance limitations.

Although every test configuration exhibited its ability to provide adequate stabilization, the various combinations had to be evaluated in relation to each other. The test film for each dummy drop was reviewed, and an arbitrary rating given to define the stability provided by the dummy's parachute assembly. Deciding factors in assigning these ratings were: average rpm, peak rpm, duration of peak rpm, presence or absence of dummy buffeting, and any other related factors which appeared. Other results of Series III tests were:

Drop 066: 9 January 1959, 95-foot balloon ascended to 52,000 feet and burst. The dummies were released from the rack at 30,000 feet. Dummy No. 1 - parachute (5-foot drogue, 28-foot main canopy) was set to open in 13 seconds. This assembly gave adequate stability. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 10 seconds. The parachute provided excellent stability.

- Drop 067: 14 January 1959, 130-foot balloon ascended to 86,000 feet and burst. The dummies were released from the rack at 68,000 feet. Dummy No. 1 - parachute (5-foot drogue, 24-foot main canopy) was set to open in 13 seconds. Stability was acceptable. The first-stage disconnect system failed to operate and the dummy rode the stabilization chute to impact. The instruments and data were recovered in a slightly damaged condition. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 13 seconds. Excellent stability was obtained.
- Drop 068: 30 January 1959, 176-foot balloon ascended to 97,000 feet. Attempts were made to release the dummies, but without success. The dummies rode the rack to ground impact and this launch was recorded as "No Test." Investigation revealed that the balloon electronic system and test package had been integrated improperly, thereby preventing cut-down.
- Drop 070: 4 February 1959, 176-foot balloon ascended to 98,000 feet. Dummy No. 1 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 20 seconds. Excellent stability. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 20 seconds, but the dummy failed to release on command and rode the rack to 15,000 feet where an emergency system affected cut-down. Although the stabilizing characteristics could not be checked out due to the low drop-altitude, the dummy was recovered in good condition.
- Drop 071: 6 February 1959, 176-foot balloon ascended to 95,000 feet. Dummy No. 1 - parachute (5-foot drogue, 24-foot main canopy) was set to open in 18 seconds. Stability was acceptable. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 10 seconds. Stability was excellent.
- Drop 072: 10 February 1959, 176-foot balloon ascended to 89,000 feet. Dummy release was attempted, but without success. The dummies rode the rack to 15,000 feet and were released by an emergency system. Dummy No. 1 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 10 seconds, and Dummy No. 2 - parachute (5-foot drogue, 24-foot main canopy) was set to open in 26 seconds. Both dummies were recovered in good condition, but no data was available on the stabilizing characteristics of the parachute due to the low release altitude.
- Drop 073: 11 February 1959, 176-foot balloon ascended to 96,000 feet. Dummy No. 1 - parachute (5-foot drogue, 28-foot main canopy) was set to open in 10 seconds. Stability was adequate. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 13 seconds. Stability was excellent, but the first-stage disconnect system failed to release and the dummy remained on the first-stage chute until ground impact.
- Drop 074: 11 February 1959, 176-foot balloon broke prior to actual launch so equipment was rescheduled for next launch.

- Drop 075: 14 February 1959, 166-foot balloon ascended to 98,000 feet. Dummy No. 1 - parachute (5-foot drogue, 24-foot main canopy) was set to open in 8 seconds. Stability was adequate. Dummy No. 2 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 10 seconds. Stability was excellent.
- Drop 076: 16 February 1959, 166-foot balloon ascended to 98,000 feet. Dummy No. 1 - parachute (6-foot drogue, 28-foot main canopy) was set to open in 10 seconds. Stability was excellent. Dummy No. 2 - parachute (5-foot drogue, 28-foot main canopy) was set to open in 10 seconds. Stability was good.

Series III and the stabilized balloon dummy drops were completed with Drop 076. Project personnel returned to this Division to evaluate the study, and determine whether or not the Series III parachute assembly was safe for live jump tests. Due to the two disconnect failures, a series of bench tests and aircraft drops were made and these resulted in more disconnect failures. Following completion of Series III, efforts were directed toward developing fail-safe disconnect hardware. Approximately 150 aircraft dummy drops were conducted here before a functionally reliable disconnect system was developed and approved.

CONCLUSIONS

The evaluation of the test results led to the following conclusions:

1. Dummies carried to extremely high altitudes by balloons can be successfully stabilized and recovered following their release.
2. The parachute developed through this project is safe for live jump testing from balloon-borne vehicles conducting human factors research on high altitude bail-out.
3. A series of live-aircraft and balloon-borne vehicle jumps should be made with this parachute, and physiological data collected during the jumps.

APPENDIX I

LAUNCH SITE PROCEDURE AND CHECK LIST

1. Remove tie-down lines from dummies arms:
 - a. Dummy No. 2 arms tied to rack diagonal brace.
 - b. Dummy No. 1 arms tied to truck side boards.
2. Inspect instrument kits for firmness to dummy. If loose, tighten kit mounting straps on both sides of kit. (One kit per Dummy)
3. Inspect all plugs to insure that they are fast. All dummy kit to harness plugs must be safety taped to prevent disconnect. Rack cut-down harness to dummy harness plugs (mounted on side at top of parachute pack) must be safetied to prevent premature disconnect but must allow quick disconnect at cut-down. Dummy with telemetry kit has 5-kit connections and 2 "shoulder" connections. Dummy with photo kit has 3 kit connections and 1 "shoulder" connection.
4. Inspect instrument kit to telemetry cable connection and insure that it is a fast connection. Disregard squib cannon present. It is not necessary.
5. Inspect cut-down squibs - 3 per dummy (1 each shoulder and 1 on feet). Make sure that kit to squib harness is safetied. Squib to squib harness connections must be safety taped.
6. Inspect kit release bracket and make sure safety wire is installed (1 per kit).
7. Inspect parachute harness to kit D-ring tie line (release side of kit) to insure security (1 per kit).
8. Inspect kit release timer setting (13,000 ft - 2 sec.) (one per kit).
9. Inspect kit release timer arming cable static line for security. (1 per dummy, both tied to foot bar of Dummy No. 2.)
10. Inspect parachute static line and insure that they are fast to dummy suspension bar (1 per dummy).
11. Install rack photo and cut-down kit - Insure that rack harness is outside kit mounts.
12. Install P-2 camera kit.
13. Install cable for 6 volt pulse from command box (2 pin plug).
14. Install cable for Dummy No. 1 kit (2 pin plug).
15. Install cable for Dummy No. 2 kit (2 pin plug).
16. Install cable for Aerial Camera pulse (3 pin plug).
17. Remove PL-55 plug from rear of Photo package (Red Streamer).
18. Install lenses - all lenses are set for f/8 and Inf. Screw lenses in cameras firmly, but do not put too much pressure on them.

19. Remove lense cover from Aerial Camera lense. Set camera at "A" setting. Turn switch on battery box to "Hazy."
20. Install balloon command cut-down box (use 6 bolts). INSURE THAT RACK HARNESS IS OUTSIDE CUT-DOWN BOX MOUNTING PLATE.
21. Install cut-down cable to balloon command box connection. (large plug)

CHECK FOR CONFIRMATION OF LAUNCH. WHEN LAUNCH IS CONFIRMED, CONTINUE WITH PROCEDURE AND CHECK LIST, BUT NOT UNTIL.

22. Remove dummy shoulder safety lines (5000 lb webbing). Untie (DO NOT CUT) webbing on one side of suspension bar and unthread line from between dummy and parachute pack. When line is free of dummy and parachute, untie other side. (One line, tied both ends, per dummy.)
23. Remove dummy foot retention safety lines. Untie - DO NOT CUT - (5000 lb webbing will be used for safety lines).
24. Remove tape covering Shoulder Camera Lens. (Lenses are to be set on f/2.7.) Wipe off any dust present.
25. Wipe kit camera windows free of dust (1 per kit).
26. Lift launch rack from truck bed and remove rack stand (6 bolts, 1 each side in front and 2 each side on back of rack). (This must be preceeded by removing the rack tie-down lines.) When this action is accomplished, drive the truck out from under the rack.
27. Connect antenna to kit cable which is threaded through antenna mounting post. Install telemetry antenna on extended antenna mounting post. Insure that ground plane of antenna is not spread and all antenna extensions are free from bending. If mounting post is not extended far enough, pull it out to the proper length to allow unforceful mounting of antenna.
28. Push buttons on cable side of each kit (2 per kit).

The rack is now ready to be launched. If time permits, IT IS VERY ADVISABLE TO AGAIN MAKE AN INSPECTION, FROM START TO FINISH, ACCORDING TO THIS CHECK LIST.....

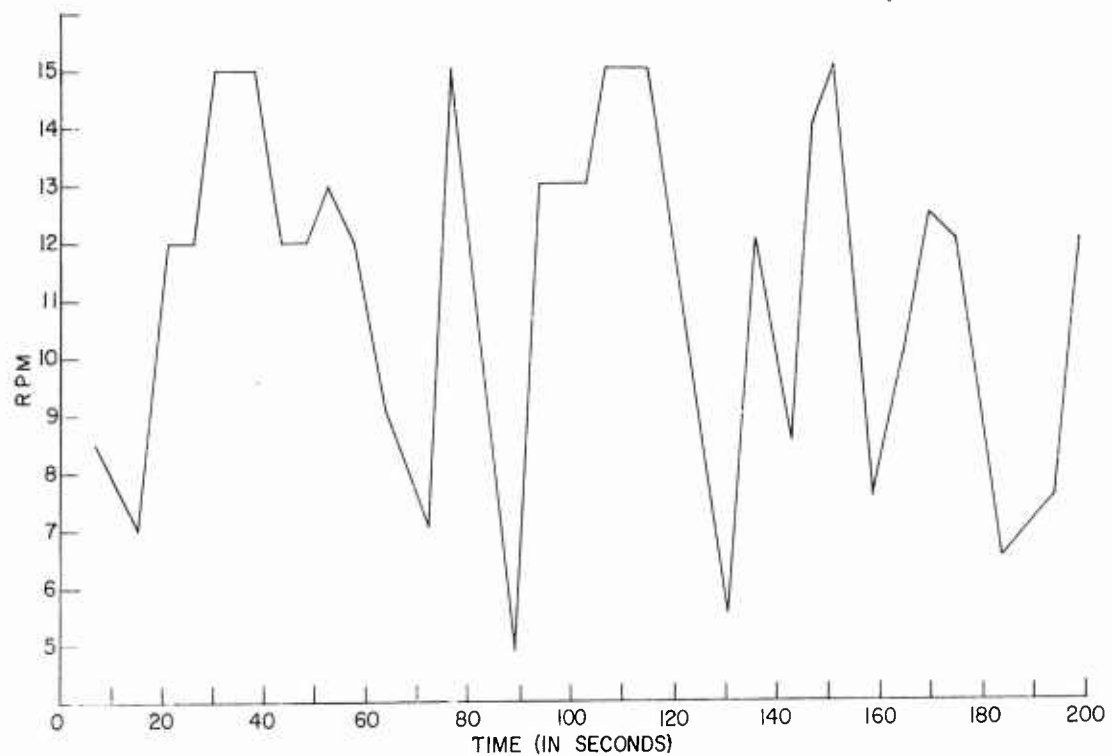


Figure 19. Series III. Data Reduction Sample Dummy Number 1, Drop Number 067

13 sec. free fall before 1st stage parachute deployment at approximately 64,000 ft (mean sea level)

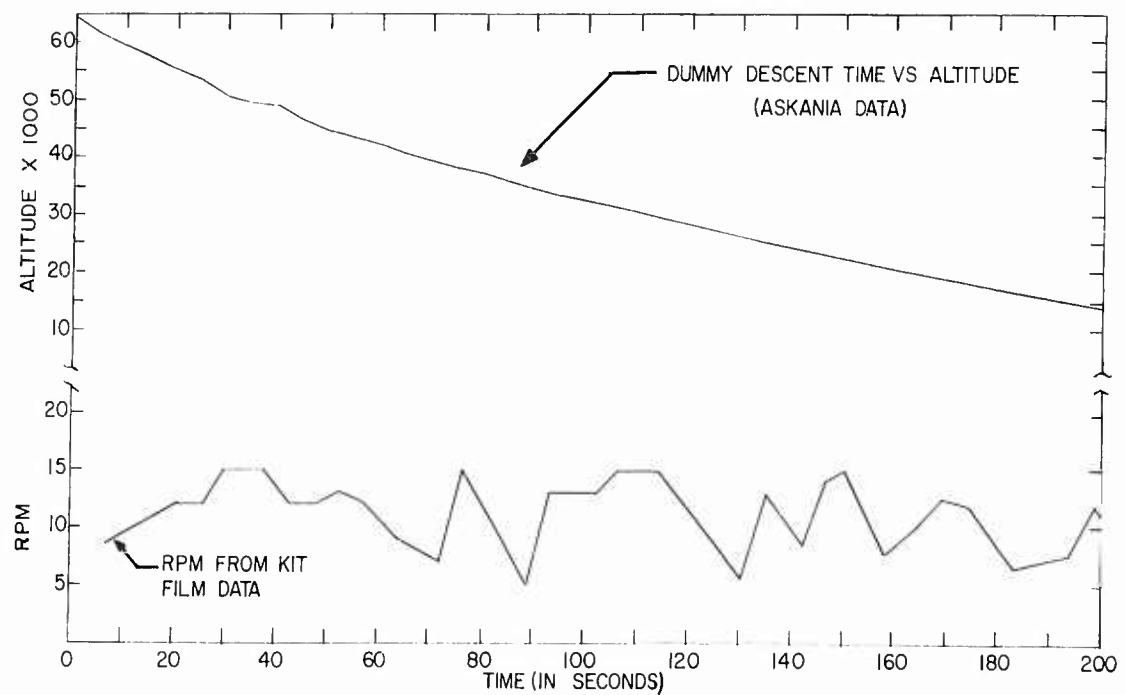


Figure 20. Series III. Data Reduction Sample, Dummy Number 1, Drop Number 067

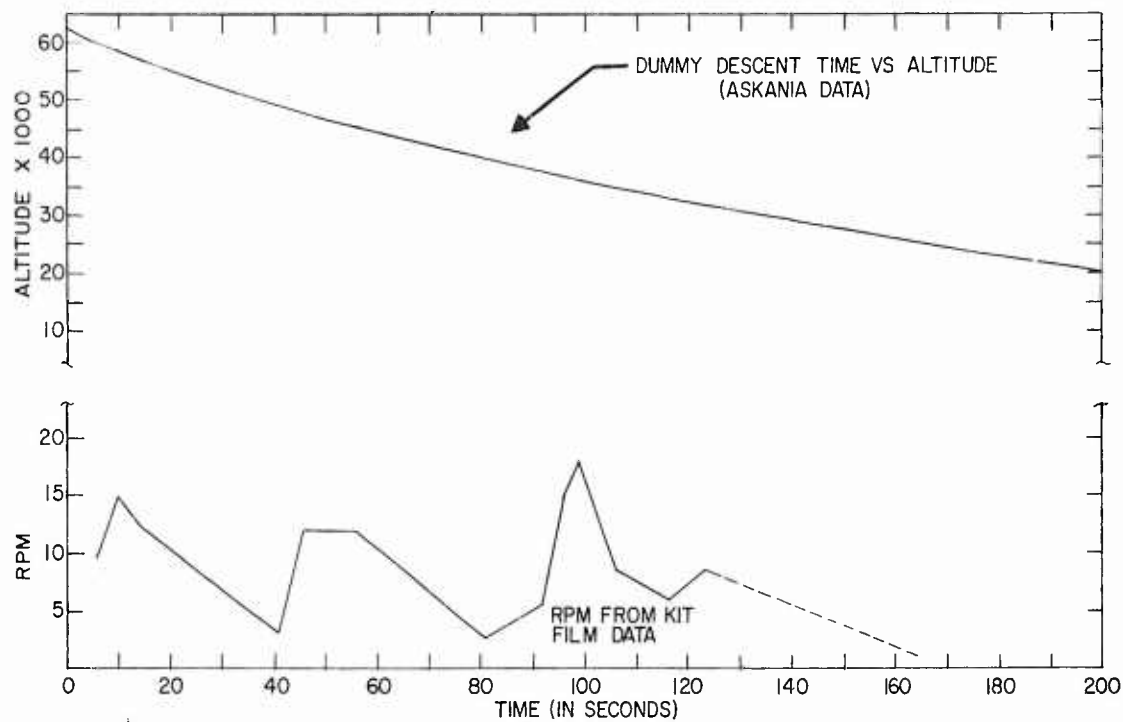
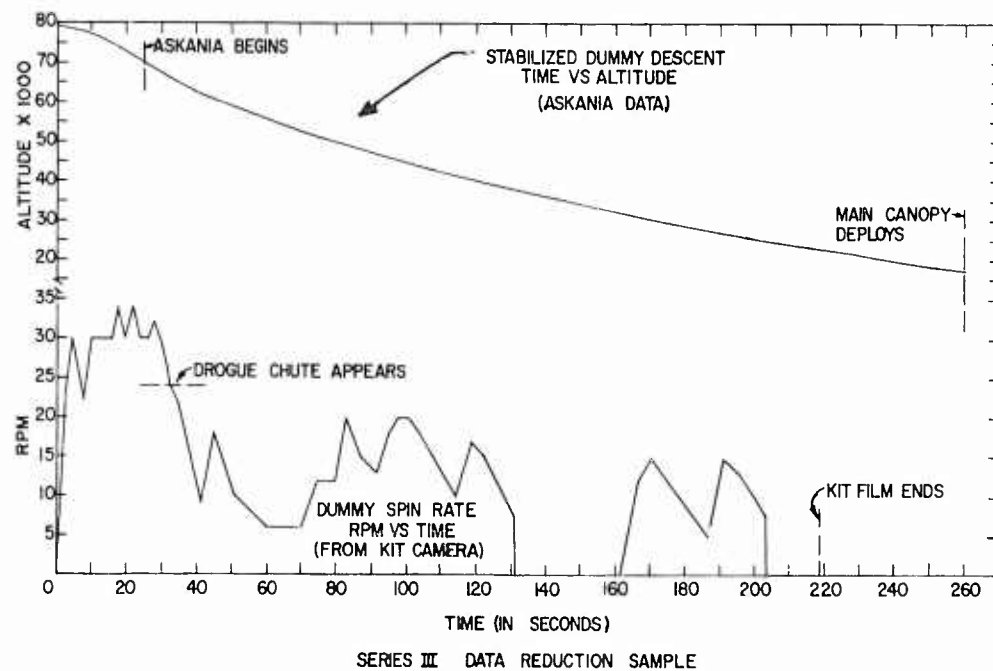


Figure 21. Series III Data Reduction Sample,
Dummy Number 2, Drop Number 067



SERIES III DATA REDUCTION SAMPLE

Figure 22. Series III Data Reduction Sample,
Dummy Number 2, Drop Number 068

<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>
<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) Instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>
<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) Instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>

<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio. HIGH ALTITUDE BALLOON DUMMY DROPS II: The Stabilized Dummy Drops, by Raymond A. Madson, 1st/Lt, USAF. 28 pp. incl. illus. (Proj. 7222; Task 71748) Unclassified report</p> <p>This study was conducted to develop a means of eliminating body tumbling, spinning, and rotation which are inherent in a long free-fall from extremely high altitude. Dummy men, wearing seat-style instrument kits and stabilization parachute assemblies, were carried to altitudes between 30,000 and 98,000 feet. They were released from the balloons by radio-command, and the</p>	<p>UNCLASSIFIED</p>
<p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>
<p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>	<p>WADC TR 57-477 (II) instrument kits recorded effectiveness of the parachutes and movements of the dummies. The tests proved that an effective means of stability could be provided and that live jumps could be made safely from high altitude with the parachute developed during this program.</p>	<p>UNCLASSIFIED</p>